Gulf of St. Lawrence Cod: Age-Specific Geographic Distributions and Environmental Occurrences from 1971 to 1981

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GULF OF ST. LAWRENCE COD: AGE-SPECIFIC GEOGRAPHIC DISTRIBUTIONS AND ENVIRONMENTAL OCCURRENCES FROM 1971 to 1981

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ABSTRACT

Tremblay, M.J. and M. Sinclair. 1985. Gulf of St. Lawrence cod: age-specific geographic distributions and environmental occurrences from 1971 to 1981. Can. Tech. Rep. Fish. Aquat. Sci. 1387: iv + 43 p.

The autumn distribution of Gulf of St. Lawrence cod is described using data from 11 groundfish surveys. Younger cod have more restricted distributions and tend to be concentrated near major spawning areas. With increasing age cod become more widely distributed and are found in deeper, colder, more saline water. The following age groups tend to covary in year-to-year geographic distribution: ages 2 and 3, 4 and 5, 6 to 8, and 9 to 11.

RÉSUMÉ

Tremblay, M.J. and M. Sinclair. 1985. Gulf of St. Lawrence cod: age-specific geographic distributions and environmental occurrences from 1971 to 1981. Can. Tech. Rep. Fish. Aquat. Sci. 1387: iv + 43 p.

La répartition automnale de la morue dans le golfe du Saint-Laurent est décrite à l'aide de données provenant de onze relevés des poissons de fond. Les morues plus jeunes obéissent à une répartition plus limitée et ont tendance à se concentrer près des principales aires de reproduction. A mesure qu'elle vieillit, la population de morue se déploie sur un plus vaste territoire et on la trouve dans des eaux à fois plus froides, plus profondes et plus salées. Les groupes d'âge suivants ont tendance à covarier dans la répartition géographique annuelle: âges: 2 et 3, 4 et 5, 6-8 et 9-11.

INTRODUCTION

The description of changes in geographic distribution with age within a population can contribute to an understanding of the factors affecting population abundance. In the southern Gulf of St. Lawrence cod, age-specific geographic distribution has been observed but has not been studied systematically. Jean (1964) found pre-commercial sized cod (<39 cm) in shallow areas (<50 m) around the Gaspé Peninsula and Magdalen Islands. Powles (1958) also noted concentrations of cod 11 to 30 cm in the shallows off Gaspé.

The cod stock complex in the southern Gulf is migratory. In summer and fall cod are found mainly between the Magdalen Islands and the Gaspé Peninsula; in winter a large proportion of these same fish are present in the Sidney Bight (Martin and Jean 1964). The extent of migration varies with size, and cod less than 39 cm remain in the Gulf during the winter (Jean 1964).

Herein, we describe the major features of age-specific geographic distribution and environmental occurrence for Gulf of St. Lawrence cod during the autumn over an 11-yr period - 1971 to 1981.

METHODS

From 1971 to 1981, 758 groundfish trawls were completed during annual September surveys in the southern Gulf of St. Lawrence (Fig. 1). The groundfish surveys were carried out using a random-stratified design (Halliday and Koeller 1981; Koeller 1981). Briefly, the southern Gulf was divided into 25 strata based on depth with a minimum sampling depth of 10 fm. During each September survey, two or more stations were randomly located within each stratum and an attempt made to trawl at these stations. In addition, 13 fixed stations were occupied annually. The data from these stations are included both in the distribution maps and the cluster analysis to be described below.

Cod numbers and lengths were determined for each station. An age-length key for each annual survey was later applied to the length frequency data to generate the age distribution for each station. Physical variables measured at each station were bottom depth, temperature, and salinity.

To provide composite maps of the geographic distribution of each age over the time period, the data were standardized to eliminate inter-annual differences in abundance. In this way, the distributional information from low-abundance years is weighted equally to that from high-abundance years. Standardization was achieved by converting the total number within each trawl to a percentage of the total number within the survey.

Age-specific environmental occurrences within each year were examined by comparing the percentage occurrence of different ages at 10-fm intervals of bottom depth, 1°C temperature intervals, and 1°/∞ salinity intervals.

To assess the similarity among the geographic distributions of cod of different ages in different years, a hierarchical cluster analysis was carried out. It was reasoned that if age had a strong effect on distribution

and annual variability was low, the age-year combinations would be clustered by age. Alternatively, if annual variability in geographic distribution was high, grouping by year regardless of age would be expected. The clustering method was Ward's, which is based on a distance coefficient and groups cases (age-year combinations) in a manner which minimizes the within-group error sum of squares (Wishart 1978). A total of 142 age-year combinations were available: ages 1 to 12 over 11 yr and age 13^+ (13^+ represents age 13 plus all older fish) over 10 yr. They were clustered based on their standardized abundance in the 19 strata sampled in each year from 1971 to 1981 (Fig. 1). The stratum abundance for each age was standardized by subtraction of the annual mean (for the age concerned) and division by the standard deviation.

RESULTS

For each of the 13 ages of Gulf cod considered, mean number per standard tow and frequency of occurrence varied considerably from year to year (Table 1). The comparitively low abundance of ages 1 and 2 is an indication of gear selectivity for larger fish (due to mesh size and/or availability). Ages 9 to 13 were lowest in abundance, presumably due to a real decline in numbers with age. With the exception of cod older than 9 yr, mean number per standard tow was generally greatest in the last 5 yr of the time series (Table 1).

The composite maps of geographic distribution by age from 1971 to 1981 (Fig. 2) show that all ages were generally most abundant in the western half of the Gulf. Concentrations of age 1 and 2 fish were most discrete and were found in three main areas: the Bay of Chaleur-Gaspé Peninsula, the northeast tip of Prince Edward Island, and Magdalen Islands. Of lesser importance was the southeast tip of Prince Edward Island.

The distribution of older cod was more widespread over the time period, and the recognition of discrete concentrations is more difficult. Older cod were found to a much greater extent in the central Gulf and along the Laurentian Channel, particularly ages 11 to 13.

For purposes of comparision with the composite maps (Fig. 2), which give the "average" distribution over the time period, maps of numbers per standard tow in each of the 11 yr for ages 1 to 8 are presented in Figures 3 to 10. On the whole, the year-to-year distribution patterns for any given age are quite similar. There is some suggestion of a more widespread distribution for some ages in years of greater abundance (as indicated by numbers per stratified tow). For example, both ages 2 and 4 were most abundant in 1979 and 1981 (Table 1) and also appear to have been more widely distributed in these years (Fig. 4 and 6).

Mean depths of occurrence for each age from 1971 to 1981 (Table 2) show clearly that Gulf cod occur at increasingly greater depths with age until about age 6. Both mean temperatures (Table 3) and salinities (Table 4) of occurrence are also age related. As age increases temperature of occurrence decreases, while salinity of occurrence increases. These relationships are not surprising given that depth, temperature, and salinity are all significantly correlated with one another (Table 5).

In most years the range of temperature, salinity, and depth experienced by any given age was large. For example, the percent occurrence in different temperature intervals for age 4 fish in 1971, 1975, and 1979 (Fig. 11) shows that not only does the temperature of occurrence vary from year to year, but it is often disjunct within any year.

The dendogram resulting from the clustering of the 142 age-year combinations has ten well-defined groups at a distance coefficient value of approximately 5 (Fig. 12). Some of the clusters were comprised mainly of similar ages (e.g. Clusters 1, 6, and 9) while others were dominated by different ages from the same year (e.g. Clusters 2 and 5). Obviously, the September geographic distribution of Gulf of St. Lawrence cod is neither totally age related nor year related. However, adjacent ages do consistently cluster out together within any given year, indicating covariance in year-to-year geographic distribution. Each of the following age groups occurred within the same cluster in 9 of 11 yr: ages 2 and 3, ages 6 to 8, and ages 9 to 11. Ages 4 and 5 clustered together in 7 of 11 yr. Ages 1, 12, and 13 clustered with adjacent ages less frequently. These ages were not abundant in the catches, however (Table 1).

DISCUSSION

The southern Gulf of St. Lawrence cod has previously been divided into 4 to 5 stocks based on vertebral numbers and tag returns. McKenzie and Smith (1955) recognized four stocks: Cape Breton, Prince Edward Island, Bay of Chaleur, and Gaspé Peninsula. Templeman (1962) recognized the same four stocks and added a fifth: a "doubtful" Magdalen Island stock.

In the present study, all but one of these stocks (Cape Breton) can be recognized as discrete concentrations in the age 1 and 2 distribution maps (Fig. 2 to 4). The division between the Bay of Chaleur and the Gaspé Peninsula concentrations is weak, and there are two concentrations around Prince Edward Island, but the juvenile aggregations generally agree with the stock designations of McKenzie and Smith (1955) and Templeman (1962). The exception is the Cape Breton stock, which is not represented as a discrete aggregation in the age 1 and 2 distribution maps. Whether the absence of a concentration there represents a sampling deficiency (insufficient proximity to shore) or a genuine lack of juveniles in the area cannot be determined from these data.

The juvenile concentrations around the northeast tip of Prince Edward Island and Magdalen Islands are coincident with egg concentrations in the generalized distribution of cod eggs depicted in Lett (1980). This suggests that for these stocks at least, the juveniles may remain close to their area of production, rather than moving to a separate nursery area.

During the period covered by the surveys (1971 to 1981), total numbers of cod in the Gulf were greatest during the last 4 to 5 yr, and this is reflected in Table 1. A detailed analysis of changes in population size during this period can be found in Sinclair and Maguire 1981 and Maguire and Waiwood 1982. In the present study there is qualitative evidence for range expansion of some ages during years of increased abundance (as indicated by number per standard tow), but it would take a sophisticated analysis of

population size estimates and an index of spread to demonstrate this phenomenon conclusively.

The predominance of young cod inshore is not explainable solely in terms of a search for preferred temperatures or salinities. Although ages 1 and 2 were found in warmer, lower salinity waters than older fish, the range of temperature and salinity experienced was quite large (Tables 3 and 4). The distribution of surface sediments (Loring and Nota 1973) does not match the distribution of young cod either - they are found on a variety of sediment types. Another factor which may contribute to the predominantly inshore distribution of young cod is their diet, which consists primarily of small crustaceans such as euphausiids and mysids (Powles 1958; Waiwood 1981). As cod increase in age their diet shifts from these prey to large invertebrates and to fish (Powles 1958; Waiwood 1981). Young cod may be found inshore simply because their food is most highly concentrated there. With increasing age cod shift to a more varied diet which includes fish and benthic invertebrates found in deeper waters.

The depth and temperature means and ranges for cod aged 4 and up (Tables 2 and 3) are similar to those reported for Scotian Shelf cod (all ages combined) (Scott 1982). One important difference is that in the Gulf of St. Lawrence preferred temperature ranges [defined by Scott (1982) as 1°C intervals in which incidence was above 10%] were often disjunct. In Scotian Shelf cod, the preferred temperature range was 3° to 7°C (all ages). Although the mean temperature of occurrence for Gulf cod aged 4 and up was always between 3° and 7°C, a substantial proportion of the population was often found in other temperature regimes. This difference may be related to differences in the oceanographic regime of the two areas, or seasonal differences in the timing of the two surveys. The Scotian Shelf survey takes place in the summer. The Gulf of St. Lawrence survey occurs in the fall when cod are found in a wider range of temperatures than at any other time of the year (Jean 1964).

The clustering of the 142 age-year combinations indicates that certain groups of adjacent ages (2 and 3, 4 and 5, 6 to 8, and 9 to 11) consistently co-occur from year to year but not necessarily in the same geographic area (stratum). To what extent aging errors contribute to the clustering of adjacent ages is unknown, but it is clear that distribution does change with age. There are several possible reasons for this phenomenon, among which are different environmental preferences, different food preferences, and greater migratory ability of older fish. The pattern of the early juvenile distributions may also reflect the specific location of spawning and subsequent egg and larval distribution within the southern Gulf.

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Table 1. Mean number per standard tow and frequency of occurrence for Gulf cod ages 1 to 13+ from 1971 to 1981. Number of occurrences is indicated in brackets. n = number of tows completed for which numbers at age available.

	Mean no. per standard tow										
Age	1971 n=53	1972 n=56	1973 n=71	1974 n=53	1975 n=46	1976 n=54	1977 n=54	1978 n=52	1979 n=63	1980 n=58	1981 n=59
1	0.1 (4)	0.5 (7)	0.1 (13)	0.2 (5)	0.6 (14)	4.0 (21)	0.7 (15)	1.4 (12)	0.2 (9)	1.2 (22)	4.2 (35)
2	0.7 (16)	2.6 (21)	6.4 (42)	2.9 (26)	7.8 (24)	8.3 (39)	9.2 (31)	5.4 (24)	27.7 (41)	4.5 (37)	18.0 (43)
3	5.3 (42)	4.9 (43)	11.7 (54)	10.6 (37)	5.1 (32)	35.8 (41)	12.4 (41)	25.0 (41)	25.4 (52)	26.1 (47)	19.0 (48)
4	7.2 (41)	14.2 (46)	4.6 (52)	8.0 (43)	7.2 (38)	8.9 (40)	11.9 (43)	21.8 (43)	49.5 (55)	20.9 (49)	62.0 (53)
5	7.0 (42)	5.4 (47)	8.0 (56)	3.0 (42)	6.3 (41)	5.5 (41)	4.6 (41)	12.5 (44)	30.5 (56)	39.0 (49)	51.6 (55)
6	5.5 (40)	5.0 (46)	4.0 (55)	3.2 (42)	2.3 (42)	2.3 (37)	2.5 (41)	4.0 (41)	13.1 (56)	21.0 (50)	50.1 (55)
7	3.5 (39)	3.7 (45)	2.9 (53)	1.2 (35)	1.6 (40)	0.6 (33)	1.4 (34)	2.4 (44)	3.5 (56)	7.9 (50)	21.3 (55)
8	0.9 (36)	1.9 (42)	2.1 (53)	0.9 (39)	1.1 (39)	0.5 (33)	0.6 (33)	0.8 (34)	1.5 (54)	1.3 (49)	11.9 (55)
9	0.2 (33)	0.4 (39)	1.4 (54)	1.0 (38)	0.5 (36)	0.3 (29)	0.4 (34)	0.3 (21)	0.7 (52)	0.6 (47)	1.7 (55)
10	0.2 (30)	0.3 (37)	0.4 (42)	0.3 (28)	0.4 (34)	0.3 (17)	0.3 (31)	0.4 (18)	0.2 (32)	0.3 (38)	0.7 (47)
11	0.1 (23)	0.2 (37)	0.1 (27)	0.2 (25)	0.4 (29)	0.2 (14)	0.2 (28)	0.3 (19)	0.2 (21)	0.1 (20)	0.3 (51)
12	0.1 (31)	0.1 (25)	0.2 (39)	0.1 (10)	0.1 (12)	0.7 (12)	0.2 (27)	0.0 (4)	0.4 (45)	0.2 (6)	0.1 (22)
13+	0.3 (32)	0.1 (6)	0.2 (39)	0.3 (17)	0.1 (5)	0.1 (11)	0.3 (30)	0.2 (10)	0.0 (0)	0.0 (10)	0.4 (16)

Table 2. Weighted mean depth of occurrence for Gulf of St. Lawrence cod aged 1 to 13+ from 1971 to 1981. In brackets is depth range over which at least 90% occurred.

	Weighted mean depth (in fathoms) of occurrence											
Age	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	$\bar{X}$
1	21.7 (11-40)	18.7 (11-30)	17.7 (11-30)	17.4 (11-30)	13.8 (11-30)	24.9 (11-40)	23.2 (11-40)	21.7 (11-40)	23.2 (11-30)	18.2 (11-40)	29.8 (11-40)	21.4
2	22.6 (11-40)	23.5 (11-40)	22.1 (11-30)	21.9 (11-40)	20.9 (11-30)	29.7 (11-40)	30.0 (11-50)	23.9 (11-40)	25.3 (11-30)	25.6 (11-40)	32.6 (11-50)	25.3
3	33.6 (11-50)	30.1 (11-40)	25.1 (11-40)	26.0 (11-40)	23.2 (11-40)	33.6 (11-70)	33.9 (11-60)	25.8 (11-50)	26.8 (11-40)	30.5 (11-50)	34.0 (11-50)	29.3
4	37.8 (11-50)	35.5 (11-60)	28.6 (11-50)	29.1 (11-40)	27.2 (11-40)	35.5 (11-70)	36.2 (11-60)	32.5 (11-50)	31.6 (11-50)	32.5 (11-50)	34.8 (11-50)	32.8
5	41.7 (11-60)	36.1 (11-60)	33.3 (11-70)	36.8 (11-80)	35.8 (11-40)	32.6 (11-70)	40.6 (11-90)	41.2 (11-70)	35.6 (11-70)	35.2 (11-70)	35.8 (11-50)	36.9
6	42.8 (11-60)	36.4 (11-60)	36.2 (11-70)	36.7 (11-80)	39.7 (11-70)	33.6 (11-50)	43.9 (11-90)	52.0 (11-90)	39.5 (11-70)	39.7 (11-70)	39.7 (11-50)	40.0
7	43.5 (11-70)	36.3 (11-60)	37.4 (11-70)	40.3 (11-80)	41.6 (11-70)	35.1 (11-70)	48.8 (11-90)	53.6 (11-100+)	43.4 (11-70)	42.1 (11-80)	44.0 (11-90)	42.4
8	42.2 (11-70)	35.5 (11-60)	37.2 (11-70)	42.0 (11-80)	45.1 (11-70)	36.0 (11-60)	51.9 (11-90)	51.5 (11-100+)	44.9 (11-70)	45.5 (21-80)	49.5 (11-90)	43.7
9	38.9 (11-60)	38.1 (11-70)	37.5 (11-70)	44.3 (11-80)	43.8 (11-70)	34.6 (11-60)	51.4 (11-90)	48.3 (11-100)	49.6 (11-100)	46.8 (21-80)	60.5 (11-100+)	44.9
10	39.5 (11-60)	34.4 (11-60)	37.9 (11-70)	54.5 (11-100+)	43.7 (11-70)	36.3 (11-80)	56.9 (11-90)	46.4 (11-100)	42.8 (11-80)	50.0 (21-90)	58.2 (11-100+)	45.5
11	38.0 (11-60)	32.0 (11-60)	40.9 (11-70)	51.7 (11-90)	41.6 (11-60)	40.6 (11-80)	53.4 (11-90)	48.5 (21-90)	52.3 (10-100+)	53.9 (21-90)	47.1 (11-90)	45.4
12	43.4 (11-90)	30.9 (11-60)	38.1 (11-60)	42.3 (11-100+)	39.3 (11-50)	46.0 (11-90)	48.4 (11-90)	52.0 (21-100+)	51.1 (11-100+)	81.6 (51-100+)	43.6 (11-90)	47.0
13	36.7 (11-60)	25.0 (11-40)	36.0 (11-70)	48.8 (11-100+)	55.7 (21-100+)	32.0 (11-60)	46.5 (21-90)	51.7 (10-100+)	- -	84.8 (31-100+)	36.5 (11-90)	45.4
$\bar{X}$	37.1	31.7	32.9	37.8	36.6	34.6	43.5	42.2	38.8	45.2	42.0	

Table 3. Weighted mean temperature of occurrence for Gulf of St. Lawrence cod aged 1 to 13+ from 1971 to 1981. In brackets is temperature range over which at least 90% occurred.

	Weighted mean temperature (°C) of occurrence											
Age	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	$\bar{X}$
1	5.8 (0-12)	7.7 (2-13)	13.0 (10-13)	5.9 (0-8)	11.5 (10-13+)	7.1 (<0-13+)	3.9 (1-8)	8.2 (0-13)	5.4 (1-12)	10.2 (1-13)	5.7 (0-9)	7.7
2	6.4 (0-12)	3.0 (<0-5)	7.5 (0-13+)	4.8 (0-8)	11.6 (10-13+)	6.8 (<0-13+)	1.8 (0-3)	7.3 (0-13)	3.4 (1-6)	6.1 (0-13)	5.6 (0-9)	5.8
3	2.4 (0-6)	3.8 (<0-10)	6.4 (0-13+)	4.9 (0-12)	9.7 (0-13+)	5.5 (<0-13+)	1.6 (0-3)	6.6 (0-13)	4.0 (0-9)	5.3 (0-13)	3.3 (0-8)	4.9
4	1.8 (0-6)	3.5 (<0-9)	5.3 (0-11)	5.6 (0-12)	7.0 (0-13+)	3.9 (<0-13+)	2.0 (0-4)	6.4 (0-13+)	4.2 (0-9)	5.4 (0-12)	2.6 (0-8)	4.3
5	1.8 (0-6)	3.5 (<0-9)	4.4 (0-11)	5.0 (0-12)	5.8 (<0-12)	3.3 (<0-9)	2.4 (0-5)	6.4 (0-13+)	4.4 (0-9)	5.1 (0-10)	2.6 (<0-5)	4.1
6	1.9 (0-6)	3.8 (<0-9)	3.8 (0-11)	4.6 (0-12)	5.2 (0-12)	2.9 (<0-8)	2.3 (0-5)	5.9 (0-13+)	4.4 (0-9)	4.9 (0-10)	2.6 (<0-9)	3.9
7	2.2 (0-6)	4.3 (<0-10)	3.5 (0-11)	4.1 (0-12)	4.8 (0-8)	2.3 (<0-8)	2.3 (0-5)	5.5 (0-12)	4.2 (0-9)	4.8 (0-10)	2.7 (0-9)	3.7
8	2.4 (0-6)	5.0 (<0-13)	3.7 (0-11)	4.1 (0-12)	4.4 (0-8)	2.2 (<0-8)	2.7 (0-5)	5.7 (0-12)	4.2 (0-9)	4.8 (0-10)	2.8 (0-9)	3.8
9	3.0 (0-6)	5.0 (<0-13)	3.6 (0-11)	3.9 (0-12)	4.3 (0-8)	2.8 (<0-8)	2.6 (0-5)	5.5 (0-12)	3.9 (0-9)	4.9 (0-10)	3.3 (<0-8)	3.9
10	3.2 (0-6)	5.5 (<0-13)	4.3 (0-11)	4.1 (0-12)	4.3 (0-8)	2.7 (<0-7)	2.9 (0-5)	5.0 (0-12)	3.7 (0-9)	5.0 (0-10)	3.8 (0-8)	4.0
11	2.2 (0-6)	4.7 (<0-13)	4.6 (0-11)	3.6 (0-12)	3.7 (<0-8)	2.0 (<0-4)	2.9 (0-5)	3.7 (0-9)	3.8 (0-6)	4.0 (0-10)	3.8 (0-8)	3.6
12	2.7 (0-6)	5.7 (<0-13)	1.7 (0-7)	3.5 (0-12)	5.2 (0-13+)	1.9 (<0-4)	2.7 (0-5)	2.4 (0-5)	3.8 (0-9)	3.4 (0-10)	4.2 (0-8)	3.4
13	2.7 (0-6)	4.0 (<0-9)	2.9 (0-11)	1.9 (0-7)	5.2 (0-13+)	5.1 (<0-13)	2.7 (<0-5)	5.6 (1-12)	- -	4.1 (1-10)	3.3 (1-8)	3.8
$\bar{X}$	3.0	4.6	5.0	4.3	6.4	3.7	2.5	5.7	4.1	5.2	3.6	

Table 4. Weighted mean salinity of occurrence for Gulf of St. Lawrence cod aged 1 to 13+ from 1971 to 1981. In brackets is salinity range over which at least 90% occurred.

	Weighted mean salinity (°/∞) of occurrence											
Age	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	$\bar{X}$
1	30.3 (28.1-32)	29.3 (27.1-31)	28.2 (27.1-29)	30.4 (29.1-32)	29.9 (29.1-30)	30.1 (28.1-32)	30.5 (29.1-32)	30.0 (28.1-32)	30.4 (28.1-32)	29.8 (28.1-32)	30.9 (29.1-33)	29.9
2	30.0 (28.1-32)	30.7 (29.1-32)	29.0 (27.1-32)	30.6 (29.1-32)	29.8 (28.1-31)	31.0 (29.1-33)	31.1 (30.1-32)	30.3 (28.1-32)	31.0 (30.1-32)	30.8 (29.1-32)	31.3 (29.1-33)	30.5
3	31.3 (29.1-33)	30.9 (27.1-33)	29.6 (27.1-33)	30.7 (29.1-33)	29.8 (28.1-32)	31.3 (29.1-33)	31.4 (30.1-33)	30.4 (28.1-33)	31.0 (30.1-33)	30.9 (29.1-33)	31.5 (30.1-33)	30.8
4	31.6 (29.1-33)	31.2 (29.1-35)	30.2 (27.1-33)	30.7 (29.1-33)	30.6 (28.1-32)	31.4 (29.1-33)	31.3 (30.1-33)	30.9 (28.1-33)	31.2 (30.1-33)	31.0 (29.1-33)	31.6 (30.1-33)	31.1
5	31.8 (29.1-33)	31.1 (29.1-35)	30.7 (27.1-33)	31.2 (29.1-34)	31.2 (29.1-34)	31.2 (29.1-33)	31.3 (29.1-33)	31.3 (28.1-33)	31.3 (30.1-33)	31.2 (29.1-33)	31.6 (29.1-33)	31.3
6	31.8 (29.1-33)	31.0 (27.1-33)	31.1 (28.1-34)	31.3 (29.1-34)	31.5 (29.1-34)	31.1 (29.1-33)	31.4 (29.1-33)	31.8 (29.1-35)	31.4 (30.1-34)	31.4 (29.1-33)	31.6 (29.1-33)	31.4
7	31.8 (29.1-34)	30.9 (27.1-34)	31.2 (28.1-34)	31.4 (29.1-34)	31.6 (29.1-34)	31.4 (29.1-33)	31.5 (29.1-34)	31.9 (29.1-35)	31.6 (29.1-34)	31.5 (29.1-34)	31.7 (29.1-34)	31.5
8	31.6 (29.1-34)	30.7 (27.1-34)	31.1 (28.1-34)	31.5 (29.1-34)	31.7 (29.1-34)	31.4 (29.1-34)	31.8 (30.1-35)	31.7 (29.1-35)	31.7 (28.1-34)	31.6 (29.1-34)	31.8 (29.1-34)	31.5
9	31.4 (29.1-34)	30.9 (27.1-34)	31.2 (28.1-35)	31.6 (29.1-34)	31.7 (29.1-34)	31.3 (29.1-33)	31.8 (29.1-35)	31.7 (29.1-35)	32.0 (29.1-34)	31.6 (29.1-34)	31.9 (29.1-34)	31.6
10	31.3 (29.1-34)	30.6 (27.1-34)	30.9 (29.1-35)	31.9 (29.1-34)	31.6 (29.1-34)	31.4 (29.1-34)	32.1 (30.1-35)	31.6 (29.1-35)	31.6 (30.1-34)	31.7 (29.1-34)	31.8 (29.1-34)	31.5
11	31.5 (29.1-33)	30.7 (27.1-34)	31.0 (29.1-33)	32.0 (29.1-34)	31.7 (30.1-34)	31.8 (29.1-34)	31.9 (30.1-34)	32.3 (30.1-34)	32.0 (29.1-35)	32.0 (29.1-34)	31.8 (29.1-34)	31.7
12	31.6 (29.1-34)	30.3 (27.1-33)	31.7 (29.1-34)	31.6 (29.1-32)	31.4 (30.1-34)	31.8 (29.1-34)	31.7 (30.1-35)	31.8 (30.1-34)	31.7 (30.1-35)	33.2 (32.1-35)	31.5 (28.1-34)	31.7
13	31.3 (29.1-33)	30.8 (29.1-33)	31.3 (28.1-34)	32.1 (31.1-35)	32.1 (28.1-35)	32.1 (29.1-34)	31.7 (30.1-35)	31.1 (29.1-34)	- -	33.2 (31.1-35)	31.3 (29.1-34)	31.6
$\bar{X}$	31.3	30.7	30.6	31.3	31.1	31.3	31.5	31.3	31.4	31.5	31.6	

Table 5. Pearson correlation coefficients among depth, temperature, and salinity at stations where cod are present - 1971 to 1981. (* = p≤0.001)

	Depth	Temperature	Salinity
Depth	-	-0.19* (n=601)	0.80* (n=601)
Temperature		-	-0.59* (n=598)

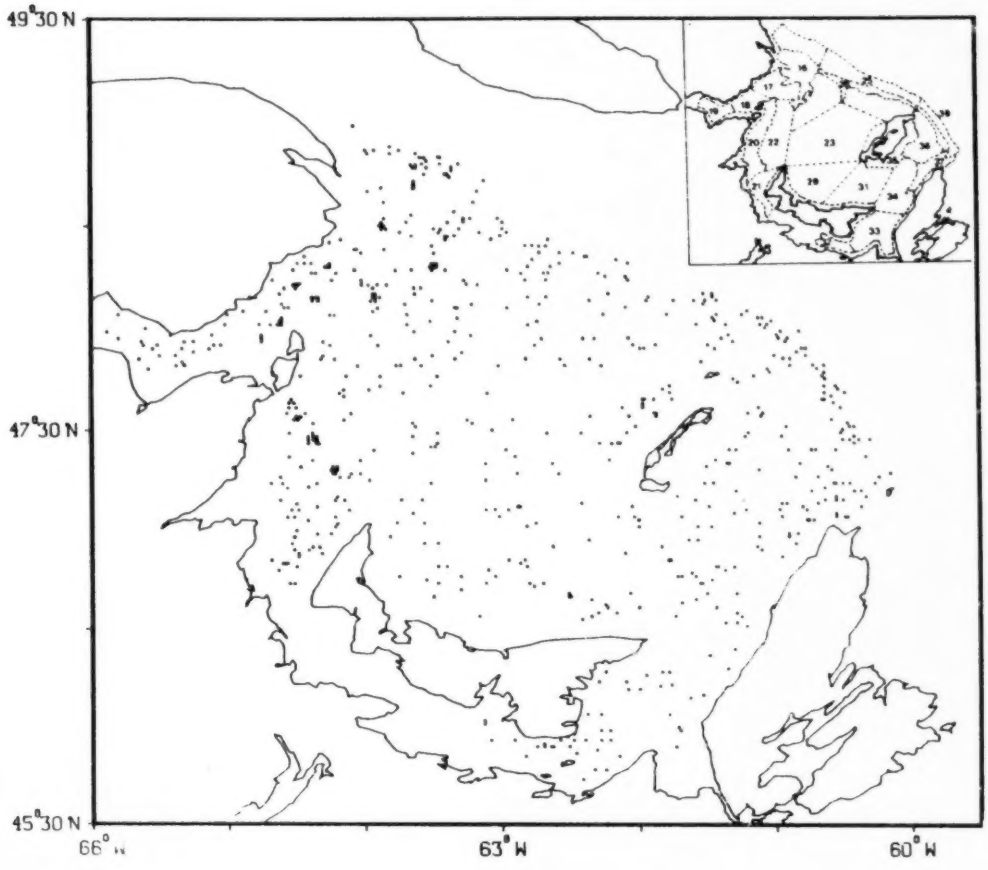

Fig. 1 Composite of stations occupied during Gulf of St. Lawrence groundfish surveys 1971 to 1981. Numbered strata in inset were used in cluster analysis.

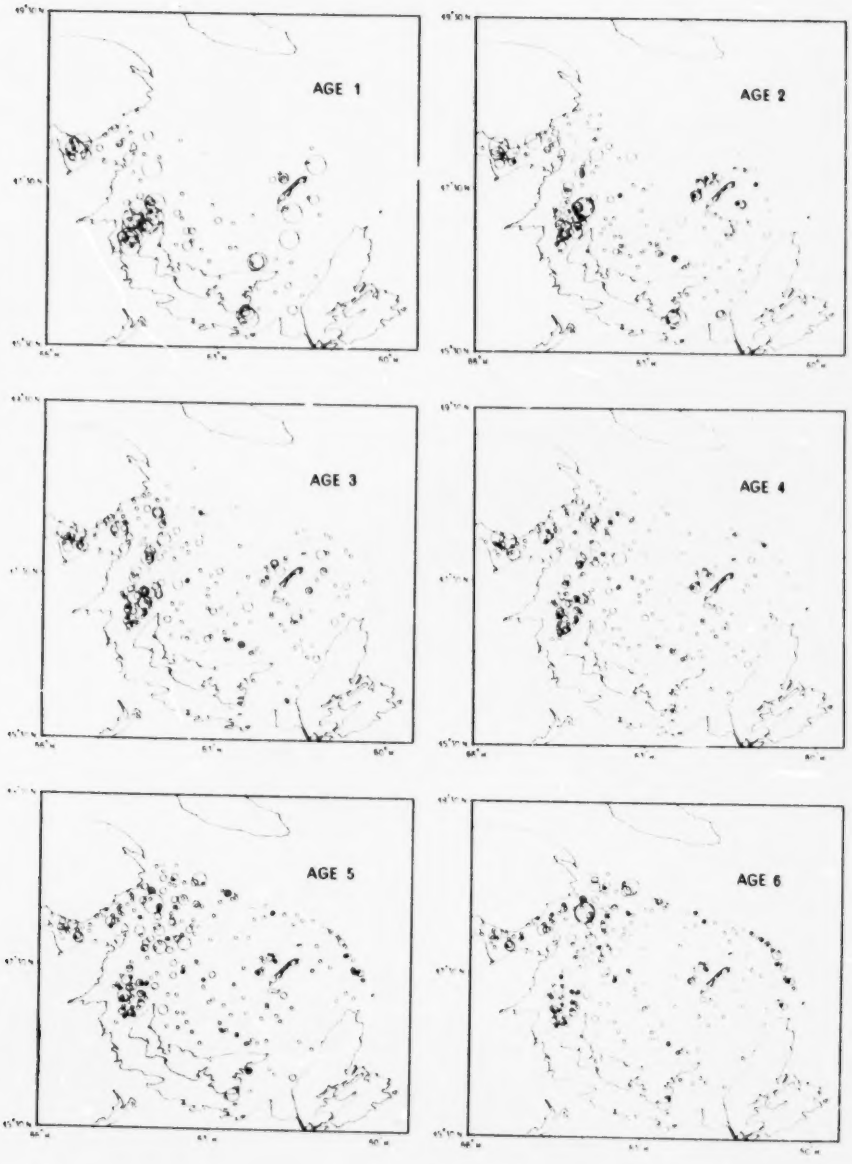

Fig. 2 Composite plots of geographic distribution for each age from 1971 to 1981 standardized by year. For each of the 11 years the percentage of the annual total number occurring at each station was determined. Beginning with the smallest, symbols are as follows: 1-5%, >5-10%, >10-15%, >15-20%, >20-25% and >25%.

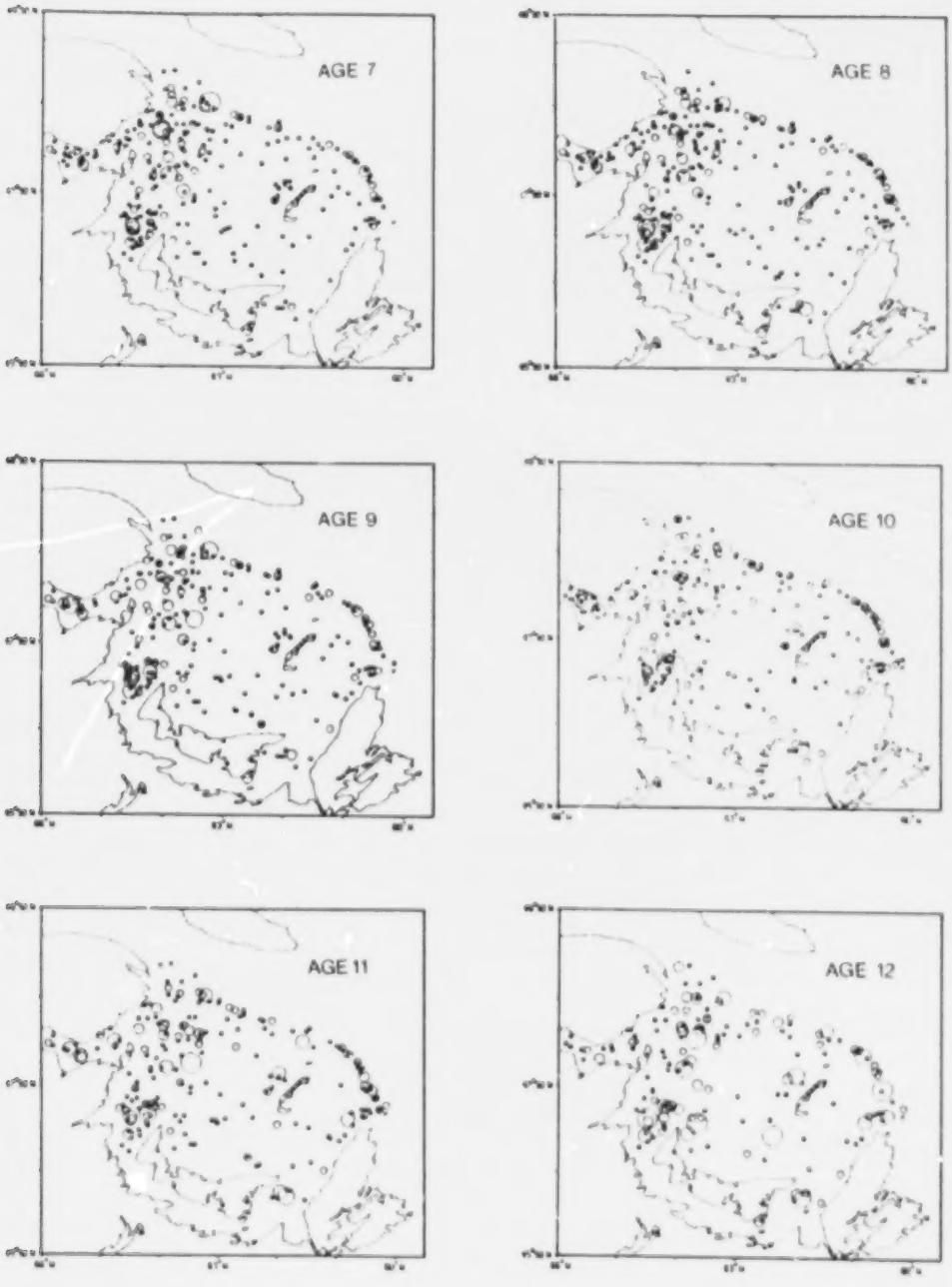

Fig. 2 (cont'd)

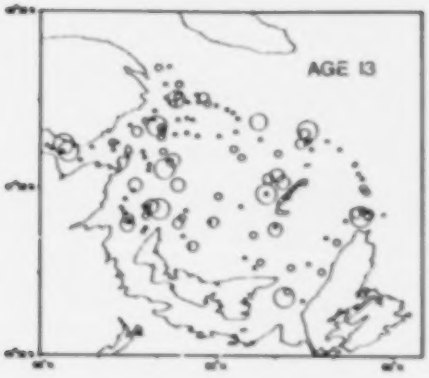

Fig. 2 (cont'd)

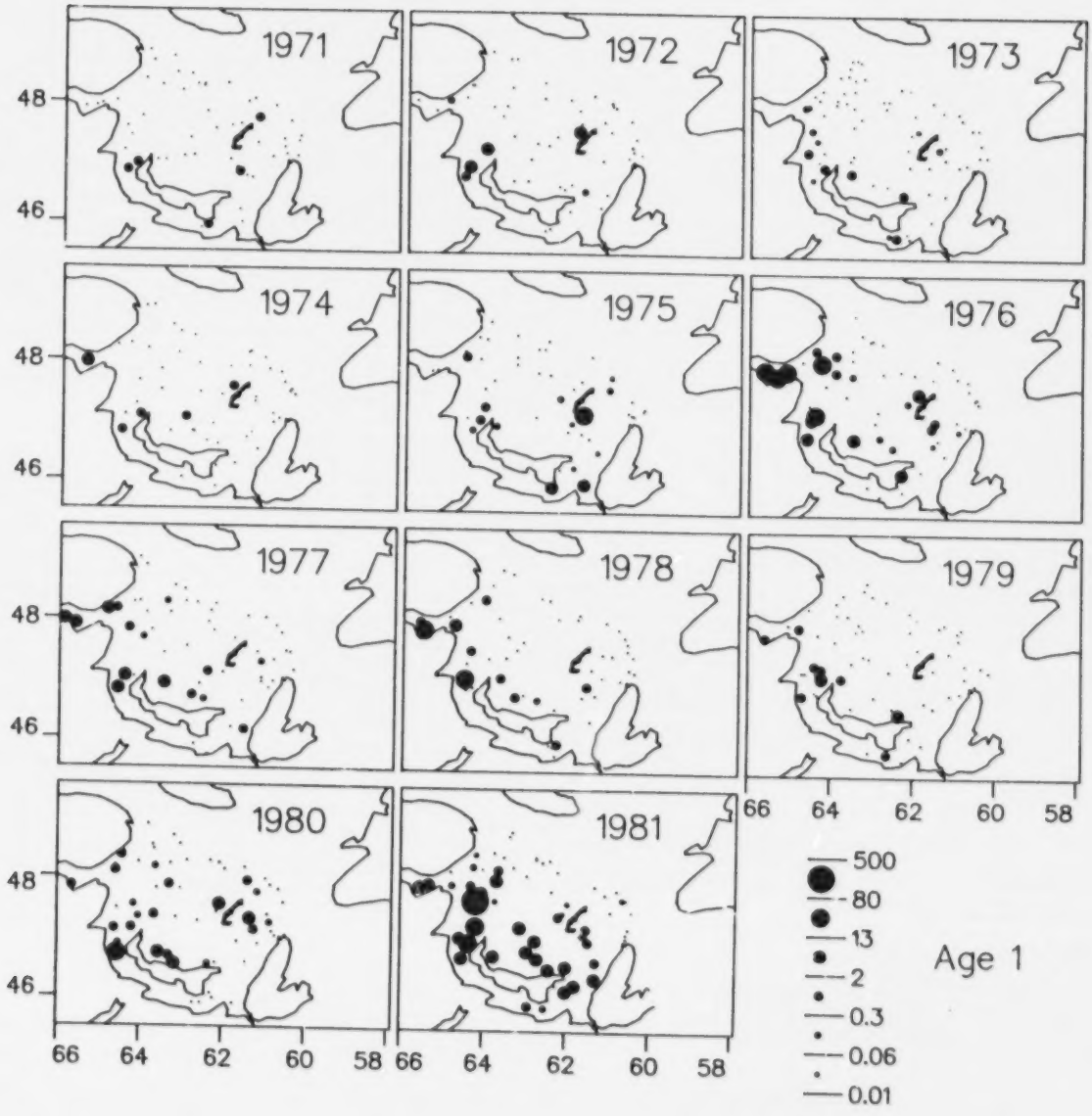

Fig. 3 The distribution of age 1 cod (number per standard tow), 1971 to 1981. Smallest dots on map are not indicated in legend and represent stations where no age 1's were found.

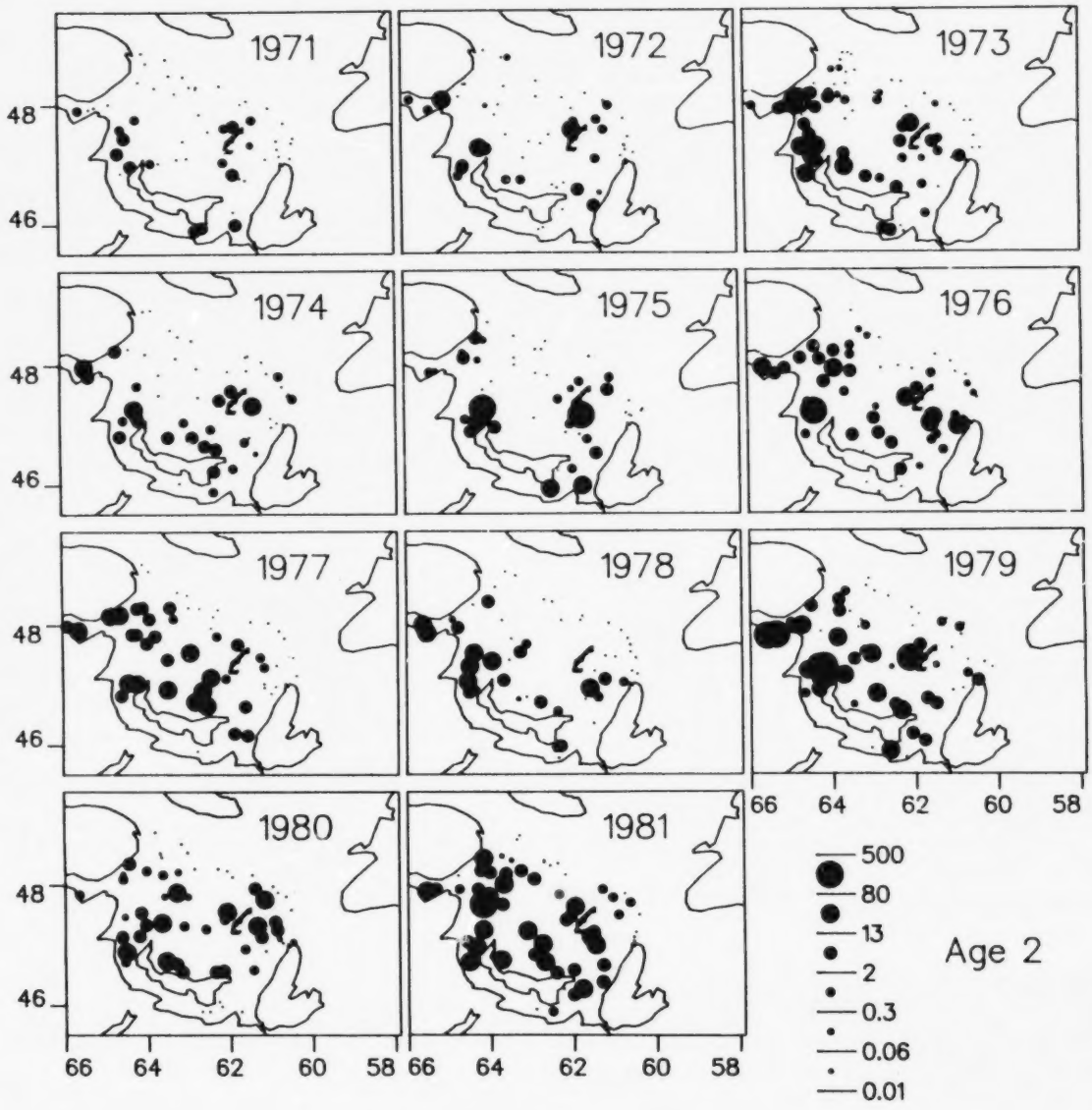

Fig. 4 The distribution of age 2 cod (number per standard tow) 1971 to 1981. See Fig. 3 legend.

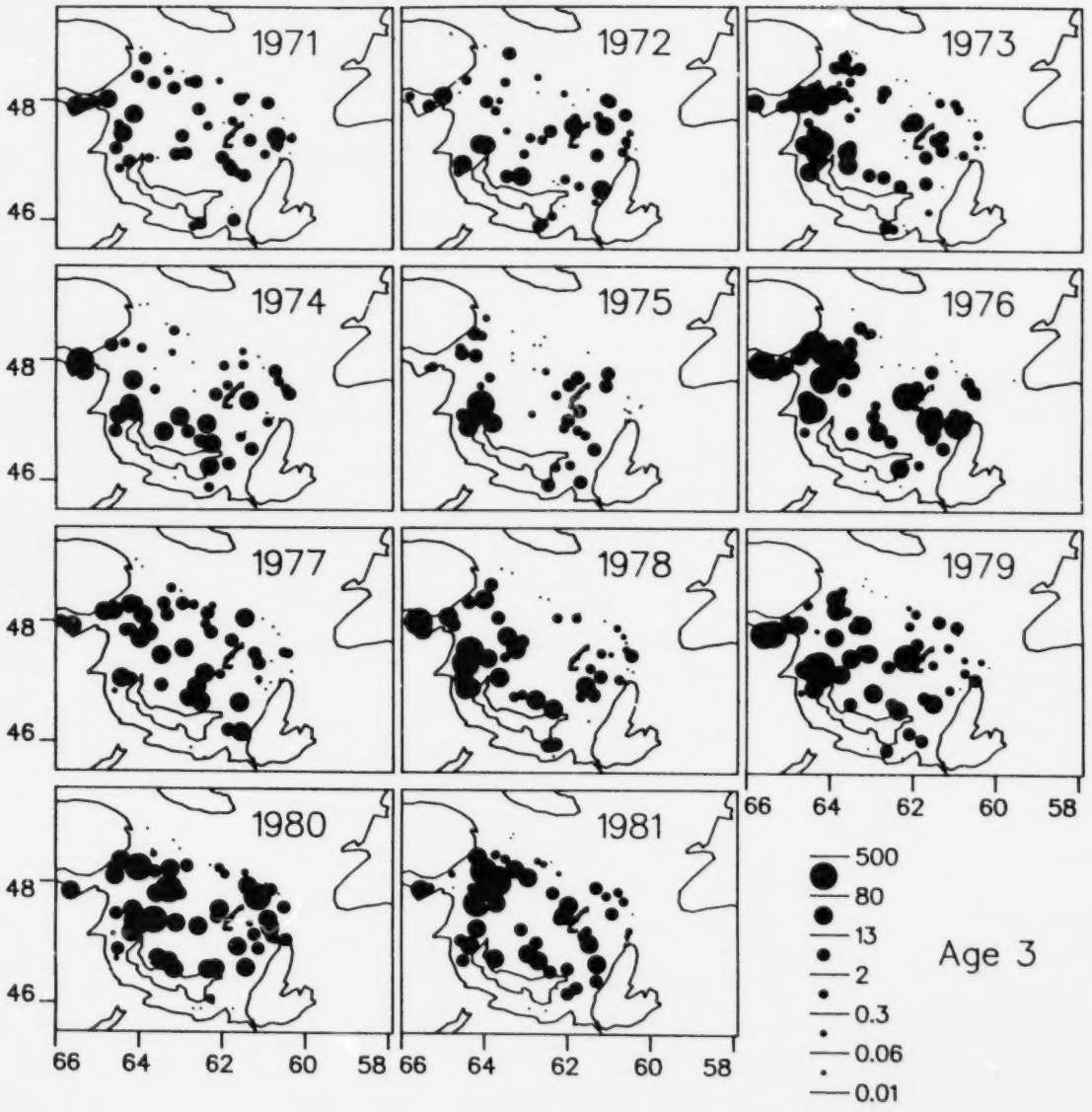

Fig. 5 The distribution of age 3 cod (number per standard tow). See Fig. 3 legend.

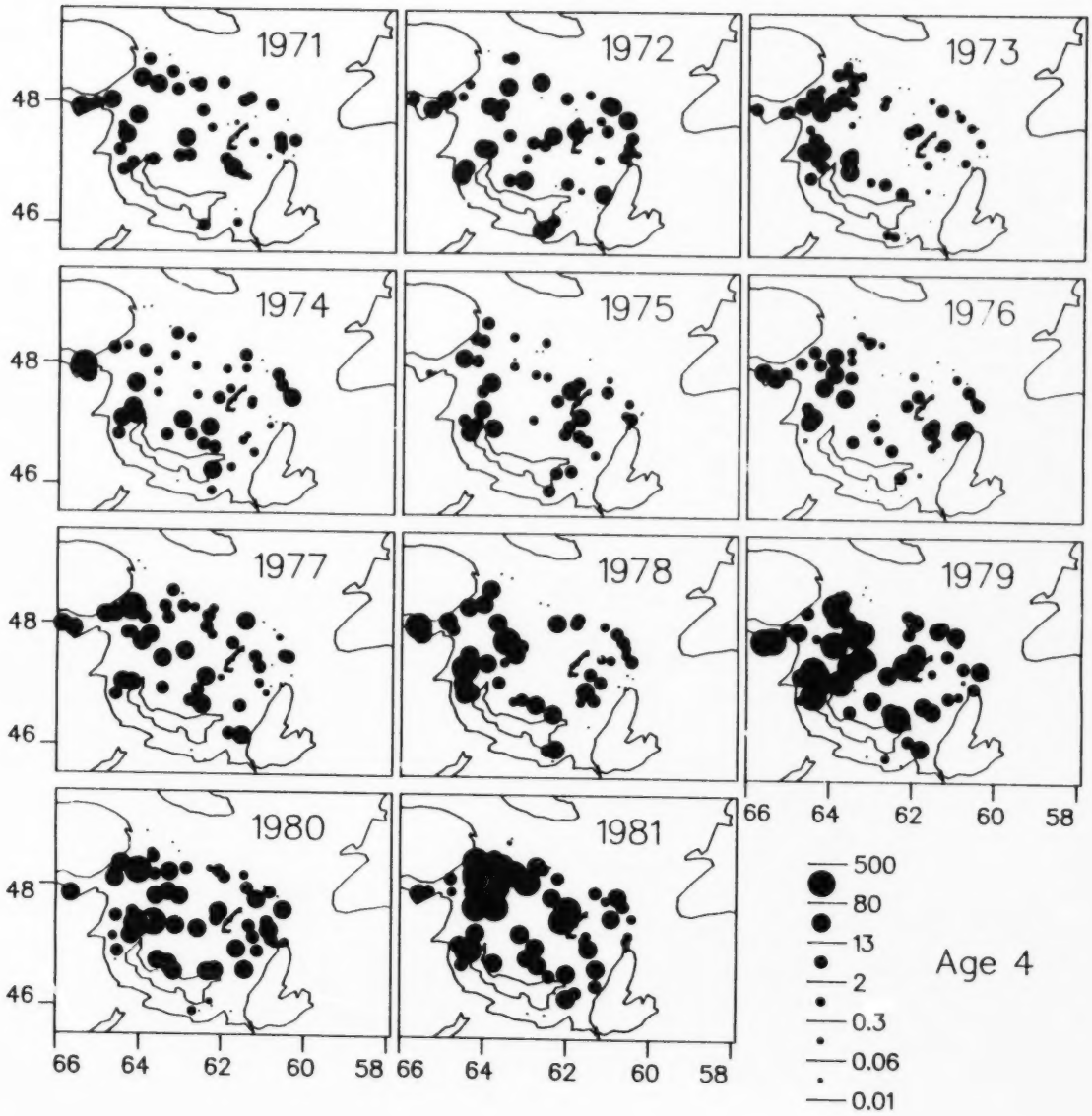

Fig. 6 The distribution of age 4 cod (number per standard tow). See Fig. 3 legend.

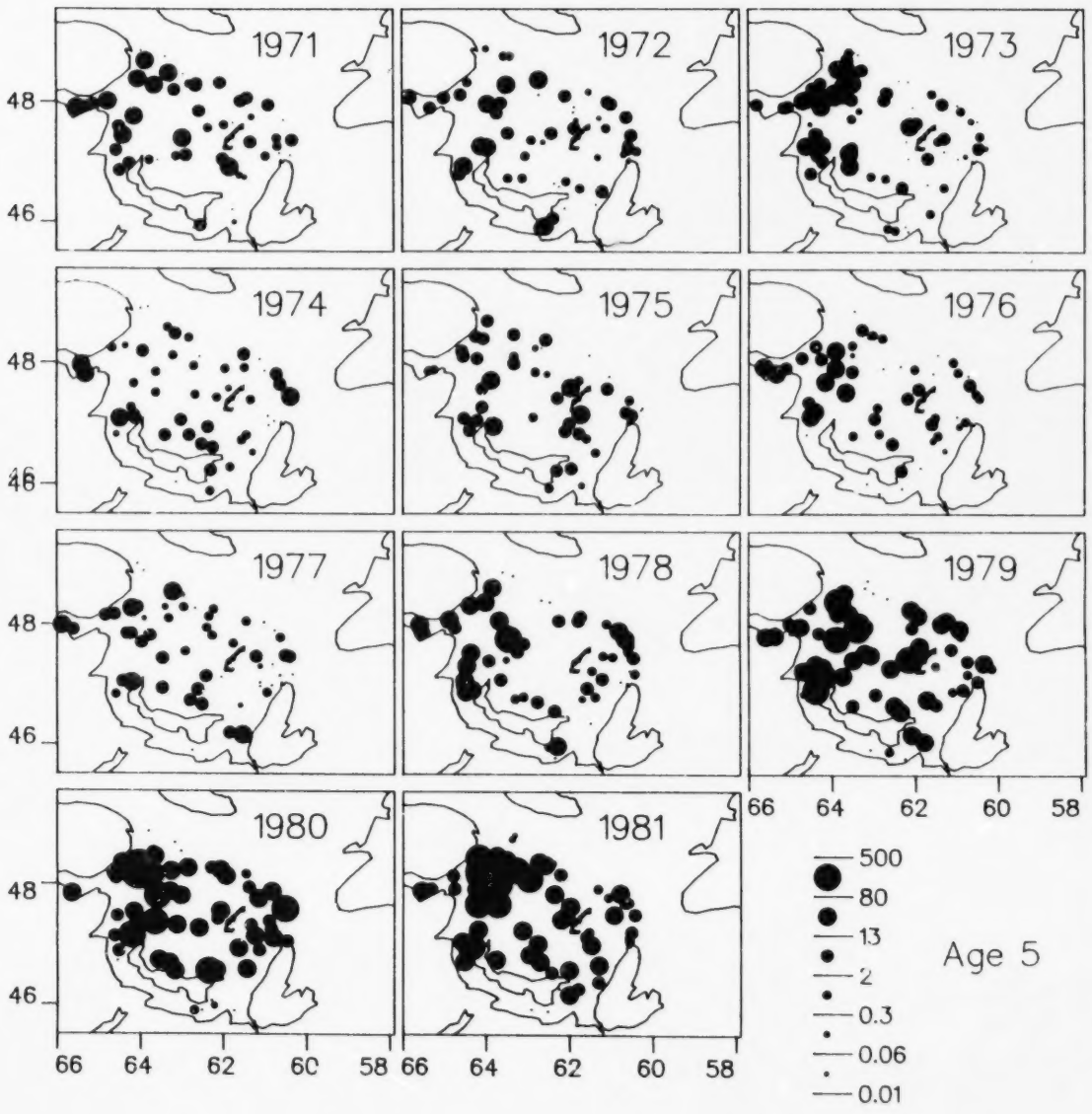

Fig. 7 The distribution of age 5 cod (number per standard tow). See Fig. 3 legend.

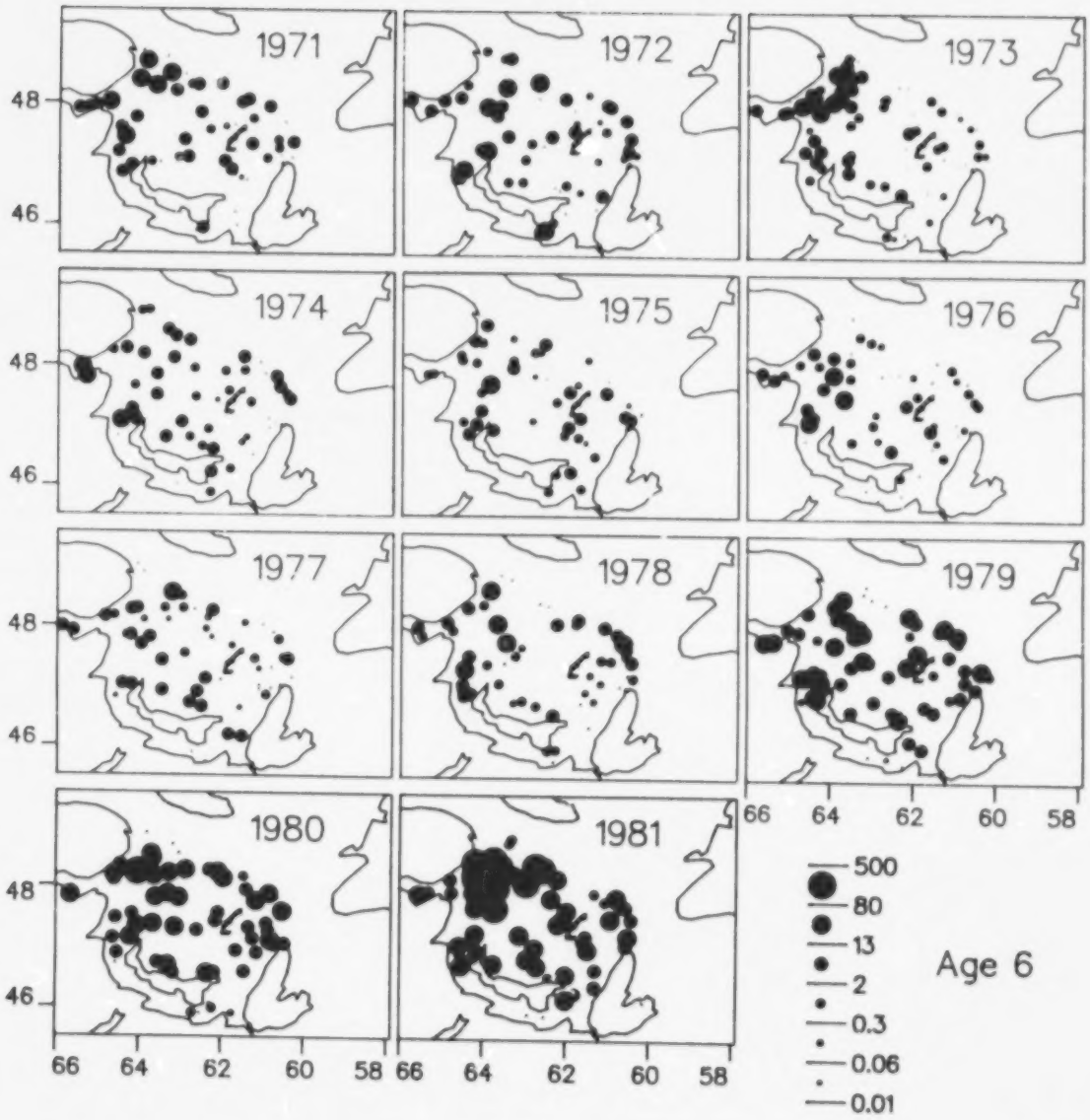

Fig. 8 The distribution of age 6 cod (number per standard tow). See Fig. 3 legend.

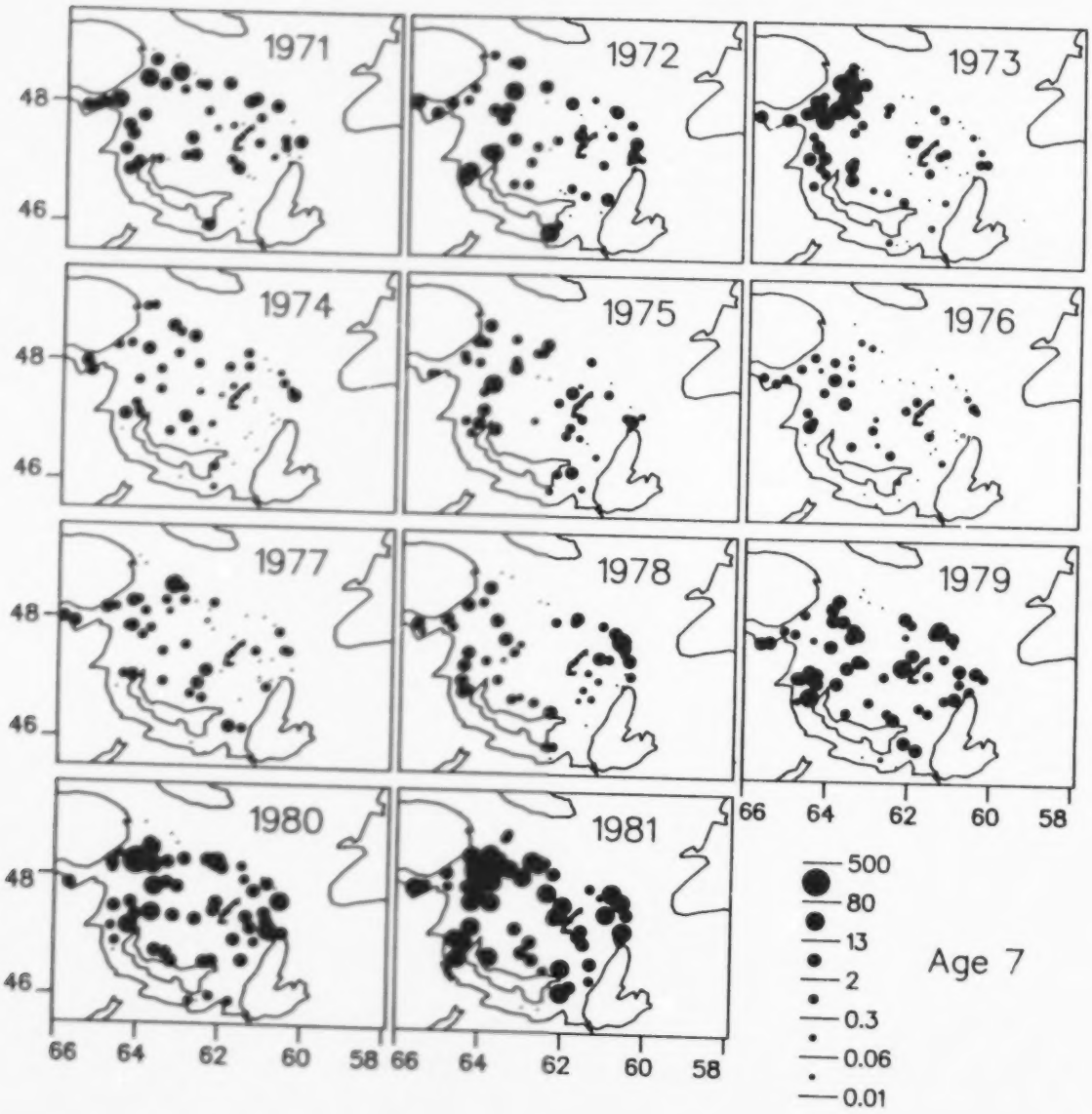

Fig. 9 The distribution of age 7 cod (number per standard tow). See Fig. 3 legend.

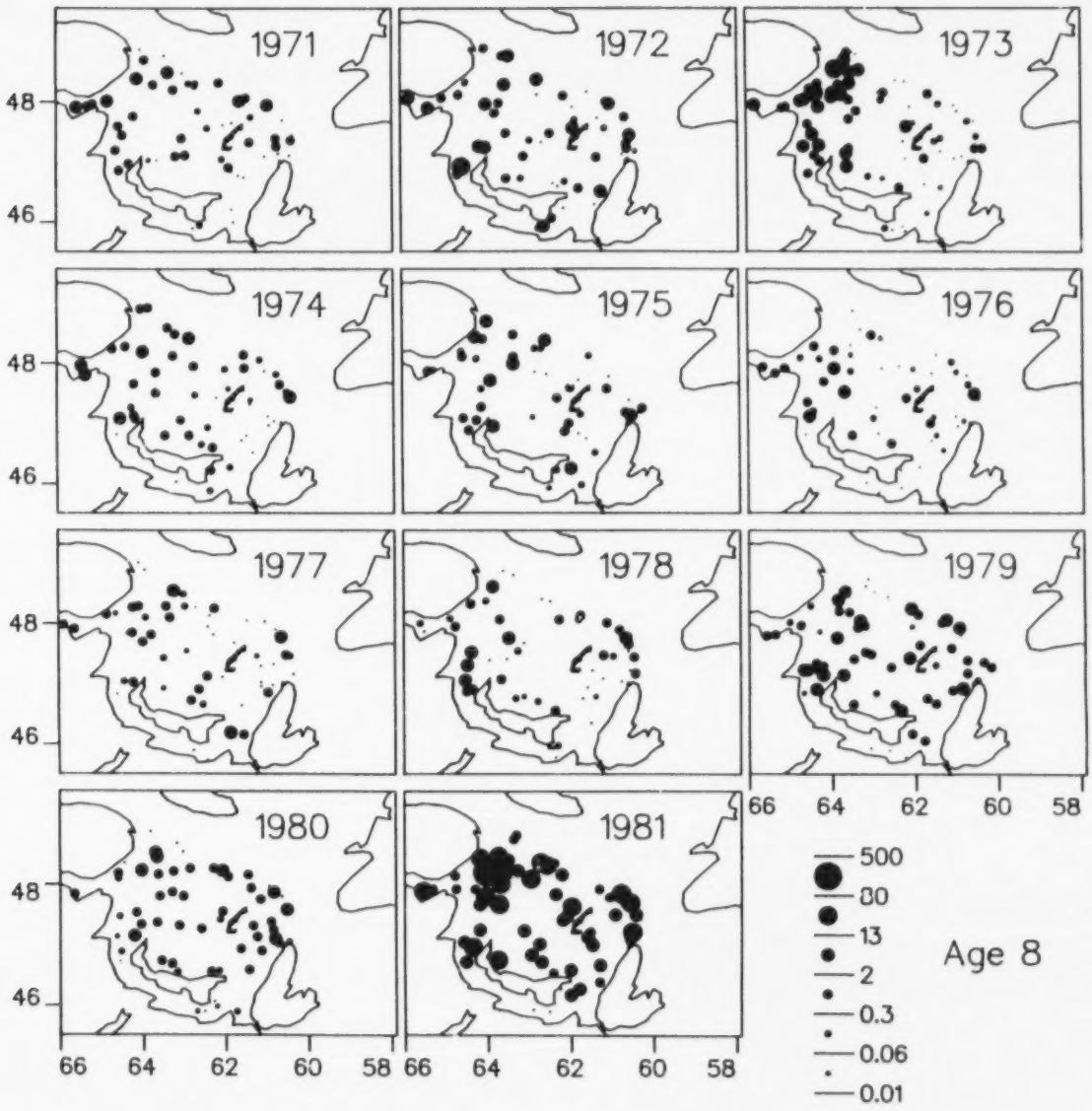

Fig. 10 The distribution of age 8 cod (number per standard tow). See Fig. 3 legend.

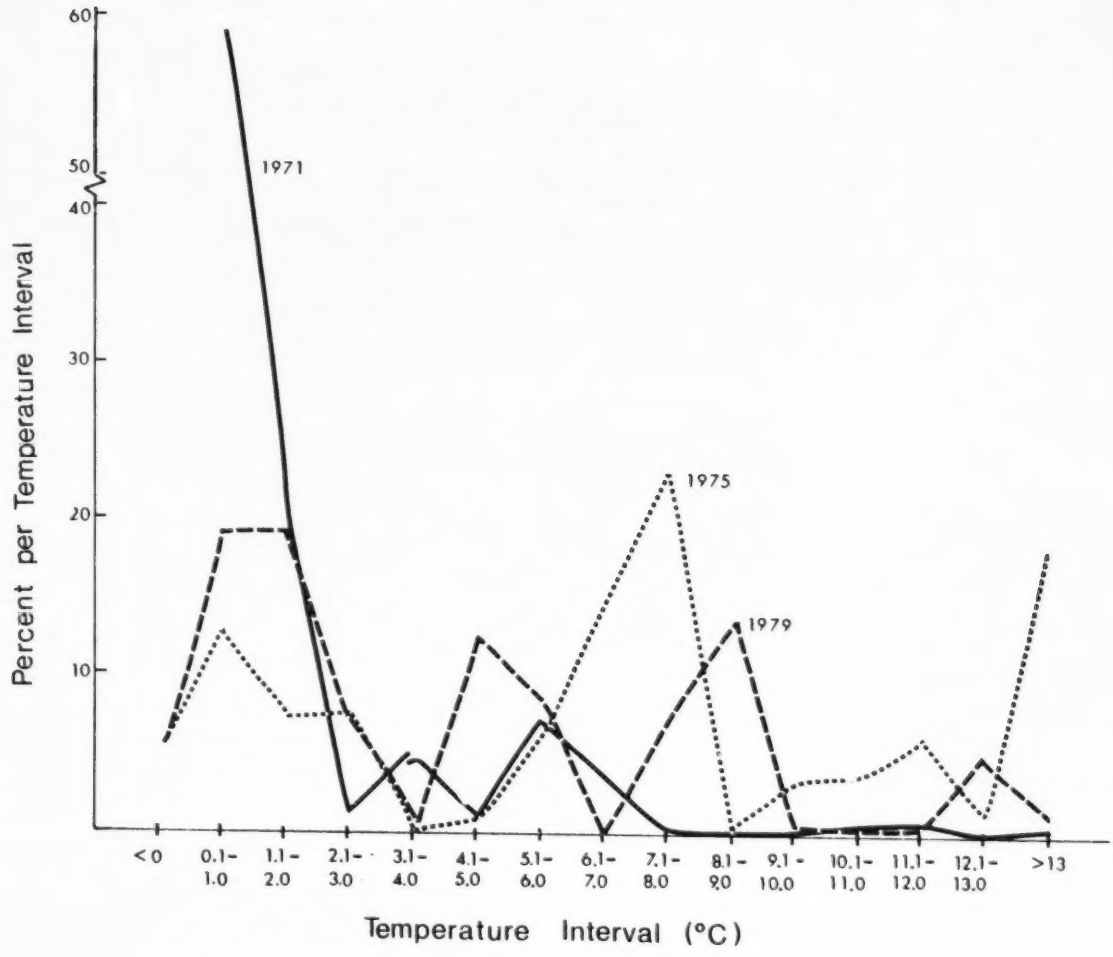

Fig. 11 Percentage of age 4 cod occurring in different temperature intervals in 1971, 1975 and 1979.

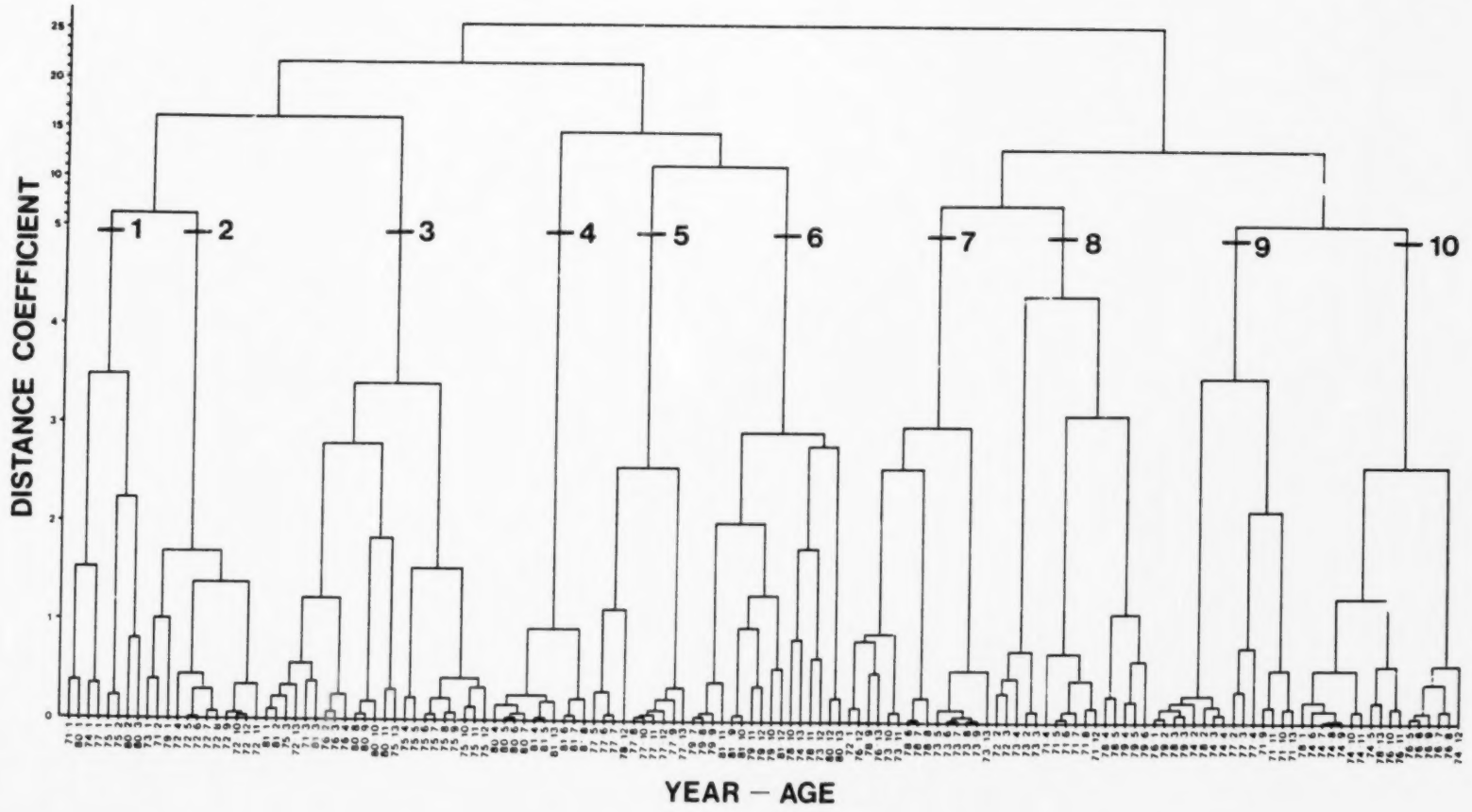

Fig. 12 Dendogram resulting from cluster analysis of 142 age year combinations of Gulf of St. Lawrence cod. Clusters of age-year combinations distinguishable at a distance coefficient of 5 are numbered 1 to 10.